



## Research Article

### Effect of Feeding Frequency on Growth Performance and Feed Utilization of *Clarias gariepinus* Juveniles

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#### ABSTRACT

Feed remains the single largest operating cost in intensive African catfish culture, and feeding frequency is a critical management practice that influences growth performance and nutrient utilization of *Clarias gariepinus* juveniles. A total of 135 *C. gariepinus* juveniles with an initial weight of 31 g were randomly stocked at 15 fish per 150 L hapa in a completely randomized design with three replicates per treatment. The fish were fed once, twice, and three times daily with a commercial diet (Blue Crown, Olam Nigeria Limited; 2 mm pellet size) at 5% of body weight for six weeks. Results showed significant differences ( $p < 0.05$ ) in final weight, weight gain, specific growth rate (SGR), feed conversion ratio (FCR), feed efficiency ratio (FER), and protein efficiency ratio (PER). Fish fed three times daily (T3) recorded the highest growth performance, with a final weight of  $171.33 \pm 1.20$  g, weight gain of  $139.83 \pm 1.07$  g, and SGR of  $4.03 \pm 0.02$  %/day, followed by T2 and T1. T3 also produced the best feed utilization indices, including the lowest FCR ( $1.18 \pm 0.02$ ) and correspondingly higher FER and PER values. Survival rates did not differ significantly among treatments. Among the water-quality parameters determined using appropriate meters, dissolved oxygen (DO) varied significantly ( $p < 0.05$ ), being highest in T1 and lowest in T3, whereas electrical conductivity (EC), pH, and total dissolved solids (TDS) showed no significant differences ( $p > 0.05$ ).

**Keywords:** African catfish; Feed conversion; Feeding frequency; Feed utilization; Specific growth rate; Survival rate ratio

**Citation:** Torsabo, D., Jonah, A.J., Jude, A.T., Solomon, A.T., Ibagye, O.M., & Solomon, S.G. (2026). Effect of Feeding Frequency on Growth Performance and Feed Utilization of *Clarias gariepinus* Juveniles. *Sahel Journal of Life Sciences FUDMA*, 4(3): 106-112. DOI: <https://doi.org/10.33003/sajols-2026-0403-11>

#### INTRODUCTION

Aquaculture continues to expand as the most rapidly growing sector of global food production, where the share of aquatic animal protein for human consumption is increasing on a daily basis (Torsabo *et al.*, 2023). In sub-Saharan Africa, Nigeria ranks as the second-largest aquaculture producer and the leading producer of African catfish, *Clarias gariepinus* (Jimoh *et al.*, 2024; Agbugui *et al.*, 2025). This species supports the national fish supply, rural livelihoods, and employment opportunity generation. Despite substantial growth in output over the past two

decades, demand still falls short for domestic production, necessitating large annual imports and underlining the urgency of improving farm-level efficiency (FAO, 2022; Ogunji and Wuertz, 2023). Feed remains the single largest operating cost in intensive and semi-intensive catfish culture, routinely accounting for 50–70% of total production expenditure (Solomon *et al.*, 2016; Limbu, 2020; Torsabo *et al.*, 2026). Many small- and medium-scale farms are faced with challenges of high feed prices, limited availability of quality feed formulations, and suboptimal delivery prices, which wear away profit

margins and threaten economic sustainability (Panda *et al.*, 2025). Consequently, any management practice that enhances feed utilization without compromising growth offers immediate practical value.

Feeding frequency is a practice that directly influences gastric evacuation rate, return of appetite, daily feed intake, nutrient digestibility, and the partitioning of ingested energy between growth and maintenance (Elesho *et al.*, 2021; Amri and Aisyah, 2025). Both underfeeding and overfeeding can impair performance: few meals may limit intake or cause compensatory hyperphagia, while frequent meals raise the metabolic cost of feeding activity and raise the risk of disease, uneaten feed, and declining water quality (Elesho *et al.*, 2021). The balance between maximizing growth rate, minimizing feed wastage, and reducing labor costs represents an optimal frequency.

Recent experimental evidence illustrates the sensitivity of *C. gariepinus* juveniles and fingerlings to meal frequency. Kolawole *et al.* (2024) reported that twice-daily feeding at 3 % body weight produced the highest specific growth rate, lowest feed-conversion ratio, and superior survival compared with once- or thrice-daily regimes. Similarly, feeding frequency has been found to exert a significant effect on African catfish fingerlings, clearly influencing both growth and feed utilization (Hossain *et al.*, 2002). Consistent with these findings, Eyo and Ekanem (2011) demonstrated that higher feeding frequency promotes faster growth, better feed efficiency, and improved survival in African catfish fingerlings fed locally formulated diets. In contrast, according to Oboh (2022), there were no statistically significant differences in weight gain or feed conversion among once-daily satiation, twice-daily every other day, and continuous twice-daily satiation; the similarity was attributed to hyperphagia that equalized cumulative intake after short periods of deprivation. Elesho *et al.* (2021) also found that growth and nitrogen retention were largely unaffected across a range of frequencies when total ration was controlled, although higher frequencies improved apparent digestibility of macronutrients while increasing maintenance energy demand. Collectively these studies demonstrate that responses are modulated by ration size, diet composition, fish size, and culture system, yet they converge on the conclusion that two to three meals per day frequently optimize the trade-off between growth and efficiency under typical Nigerian conditions.

The present study, therefore, examines the effects of varying feeding frequency on growth performance

and feed utilization of *C. gariepinus* juveniles and physicochemical parameters of the culture system. By evaluating weight gain, specific growth rate, feed-conversion ratio, and survival across different feeding regimes, the work aims to refine practical feeding guidelines that simultaneously improve biological efficiency and economic return in Nigerian catfish aquaculture.

## **MATERIALS AND METHODS**

### **Study Area**

This experiment was conducted at the University hatchery of the Department of Fisheries and Aquaculture, Joseph Sarwuan Tarka University, Makurdi, Benue State, Nigeria.

### **Experimental Fish**

A total of 135 *C. gariepinus* juveniles (initial weight 31 g) were sourced from a reputable fish farm in Makurdi. The fish were transported in plastic bags containing fresh water to the Department of Fisheries and Aquaculture hatchery. The fish were acclimatized for 7 days in an indoor circular plastic tank under laboratory conditions.

### **Experimental Design**

The experiment was conducted using a completely randomized design (CRD). Nine hapa nets, each with a dimension of 1 m × 0.5 m × 0.5 m (150 L) suspended in a large pond. The hapa were cleaned regular to avoid glugging and improve water flow. Three treatments (T1, T2, and T3) were applied, each with three replicates (R1, R2, and R3).

Treatment (T1) was fed once a day with blue crown feeds with crude protein 40–45% and 12 % lipid (2 mm) at 9:00 am; treatment (T2) was fed twice a day at 9:00 am and 1:00 pm, while treatment (T3) was fed three times a day at 9: am, 1: pm and 5: pm respectively, with experimental diets at 5% body weight on every feeding time every day for a period of six (6) weeks. Leftover feed at the bottom of the water was removed on a daily basis.

### **Determination of physicochemical water parameters**

The following physicochemical parameters were determined in situ. Dissolved oxygen (DO) was measured using a digital dissolved oxygen meter (YSI Pro20, YSI Inc., USA). Electrical conductivity (EC), total dissolved solids (TDS), pH, and temperature were measured using a PHT-027 multi-parameter water quality monitor (Zhejiang Top Cloud-Agri Technology Co., Ltd., China). This instrument provides simultaneous readings of pH, EC, TDS, and temperature, and also indicates the overall ionic content and salinity of the water. Temperature was

further verified with a digital thermometer (Hanna HI98501, Hanna Instruments, Romania). All probes were immersed directly into the water, and readings were recorded after stabilization.

#### Growth Parameters Measurement

The growth performances of the juveniles were measured after every 7 days (one week). Parameters that were measured are weight gain and length of the juveniles. The weight was taken using a digital weighing balance (Ohaus 2000 model). The total lengths of the fish measured to the nearest cm with the aid of a transparent meter rule.

#### Determination of Growth Parameters and Nutrient Utilization

Growth and nutrient utilization parameters were evaluated using the following formulas as described by De Silva and Anderson (1994), Halver and Hardy (2002), and NRC (2011).

$$\text{Mean Weight Gain (MWG)} = \frac{\text{Final mean weight (g)} - \text{Initial mean weight (g)}}{\text{Initial mean weight (g)}} \times 100$$

$$\text{Mean Length Gain (MLG)} = \frac{\text{Final mean length (cm)} - \text{Initial mean length (cm)}}{\text{Initial mean length (cm)}} \times 100$$

$$\text{Specific Growth Rate (SGR)} = \frac{\ln \text{ final mean weight} - \ln \text{ initial mean weight}}{\text{Experimental duration (days)}} \times 100$$

$$\text{Survival Rate (SR \%)} = \frac{\text{Total number of fish harvested}}{\text{Total number of fish stocked}} \times 100$$

$$\text{Feed efficiency ratio (FER)} = \frac{\text{weight gain by fish}}{\text{Weight of feed fed}} \times 100$$

$$\text{Feed Conversion Ratio (FCR)} = \frac{\text{Total amount of dry feed consumed (g)}}{\text{Wet weight of the fish (g)}}$$

$$\text{Protein Efficiency Ratio (PER)} = \frac{\text{Fish weight gain (g)}}{\text{Protein gain}} \times 100$$

#### Data Analysis

All data collected were subjected to one-way analysis of variances (ANOVA) using SPSS version 25.0.

Significant differences among treatment means were separated using Duncan's multiple range test at  $p < 0.05$ . Results were expressed as mean standard error.

## RESULT

### Growth Performance of *Clarias gariepinus* Juveniles

The growth performance of *Clarias gariepinus* juveniles fed at different feeding frequencies is presented in Table 1. Final weight, weight gain, specific growth rate (SGR), feed conversion ratio (FCR), feed efficiency ratio (FER), and protein efficiency ratio (PER) all showed significant differences ( $p < 0.05$ ). Fish fed three times daily (T3) had the best growth performance — with the highest final weight ( $171.33 \pm 1.20$  g), weight gain ( $139.83 \pm 1.07$  g), and SGR ( $4.03 \pm 0.02$  %/day). Fish fed twice daily (T2) came next, while fish fed once daily (T1) had the least growth. The FCR values were lowest in T3 ( $1.18 \pm 0.00$ ). Similarly, FER and PER were highest in T3, showing better feed and protein utilization. Survival rates range from 95% to 98% and were similar across treatments with no significant difference.

### Water Quality Parameter

The water quality parameters monitored during the experimental period are presented in Table 2. Dissolved oxygen (DO) varied significantly ( $p < 0.05$ ) among the treatments. The highest DO value ( $6.48 \pm 0.22$  mg/L) was recorded in fish fed once daily (T1), followed by those fed twice daily (T2) with  $5.85 \pm 0.19$  mg/L, while the lowest value ( $5.21 \pm 0.17$  mg/L) occurred in fish fed three times daily (T3). In contrast, electrical conductivity (EC), pH, total dissolved solids (TDS), and temperature showed no significant differences ( $p > 0.05$ ) among the treatments and remained within acceptable ranges for the culture of *C. gariepinus*.

**Table 1: Growth indices of *Clarias gariepinus* juveniles fed at different feeding frequencies.**

| Growth Indices     | T1 (once daily)            | T2 (twice daily)           | T3 (three times daily)     | p-value |
|--------------------|----------------------------|----------------------------|----------------------------|---------|
| Initial weight (g) | 31.47 ± 0.33               | 31.93 ± 0.18               | 31.50 ± 0.25               | 0.42ns  |
| Final weight (g)   | 142.33 ± 1.20 <sup>c</sup> | 156.33 ± 1.20 <sup>b</sup> | 171.33 ± 1.20 <sup>a</sup> | <0.01   |
| Weight gain (g)    | 110.87 ± 1.53 <sup>c</sup> | 124.40 ± 1.03 <sup>b</sup> | 139.83 ± 1.07 <sup>a</sup> | <0.01   |
| SGR (%/day)        | 3.59 ± 0.04 <sup>c</sup>   | 3.78 ± 0.01 <sup>b</sup>   | 4.03 ± 0.02 <sup>a</sup>   | <0.01   |
| FCR                | 1.45 ± 0.04 <sup>b</sup>   | 1.30 ± 0.03 <sup>ab</sup>  | 1.18 ± 0.00 <sup>a</sup>   | 0.04    |
| FER                | 0.69 ± 0.02 <sup>b</sup>   | 0.77 ± 0.04 <sup>ab</sup>  | 0.85 ± 0.02 <sup>a</sup>   | 0.03    |
| PER                | 1.64 ± 0.05 <sup>b</sup>   | 1.83 ± 0.04 <sup>ab</sup>  | 2.02 ± 0.04 <sup>a</sup>   | 0.03    |
| Survival rate %    | 98                         | 97                         | 95                         | 0.83ns  |

Means on the same row having different superscripts are statistically significant. ( $p < 0.05$ )

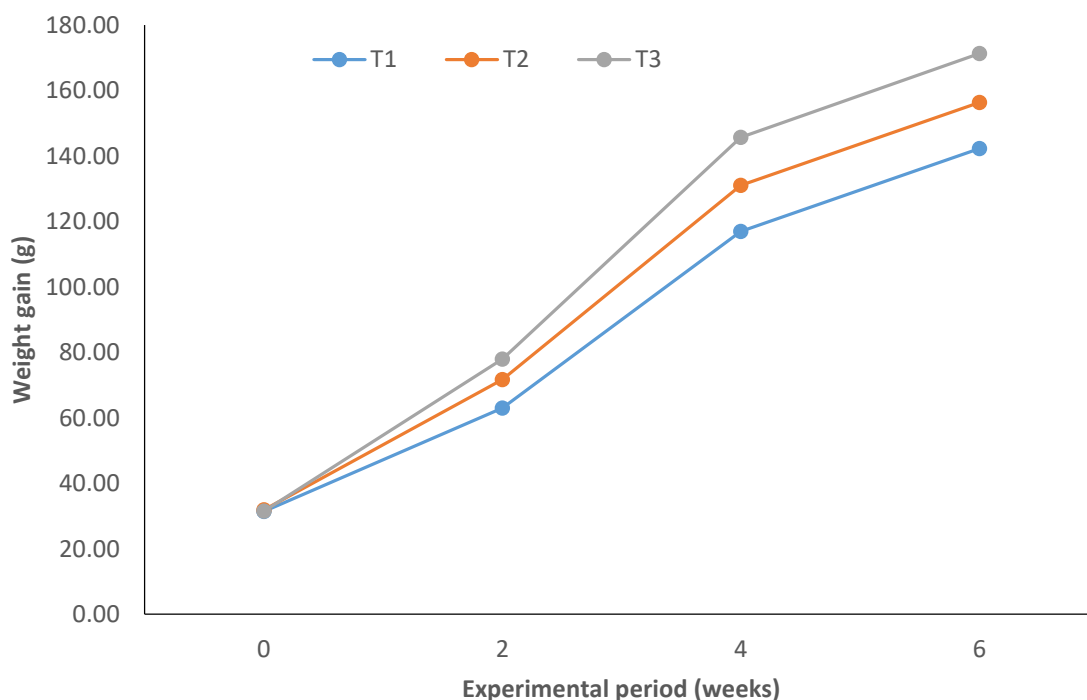


Figure 1: Growth trend of *Clarias gariepinus* juveniles fed at different feeding frequencies

Table 2: Water quality parameters during the experimental period

| Variables  | T1 (once daily)          | T2 (twice daily)         | T3 (three times daily)   | p-value |
|------------|--------------------------|--------------------------|--------------------------|---------|
| DO (mg/L)  | 6.48 ± 0.22 <sup>a</sup> | 5.85 ± 0.19 <sup>b</sup> | 5.21 ± 0.17 <sup>c</sup> | <0.01   |
| EC (μS/cm) | 785.60 ± 28.40           | 812.35 ± 15.20           | 825.10 ± 12.85           | 0.28ns  |
| pH         | 6.92 ± 0.08              | 6.85 ± 0.06              | 6.78 ± 0.09              | 0.19ns  |
| TDS (mg/L) | 405.25 ± 6.15            | 412.80 ± 5.40            | 418.55 ± 4.90            | 0.41ns  |
| Temp (°C)  | 28.15 ± 0.85             | 28.42 ± 0.72             | 28.65 ± 0.68             | 0.67ns  |

Note: results are presented as standard error of the mean (SEM); ns = not significant. Different superscripts (<sup>a</sup>, <sup>b</sup>) indicate significant differences ( $p < 0.05$ )

## DISCUSSION

The present study demonstrated that feeding frequency significantly influenced the growth performance and feed utilization of *C. gariepinus* juveniles. Fish fed three times daily (T3) recorded the highest final weight, weight gain, and specific growth rate, followed by those fed twice daily (T2), while once-daily feeding (T1) produced the lowest values. These results indicate that increasing the number of daily meals enhanced growth under the conditions of *C. gariepinus* in this study.

The superior growth observed in fish fed three times daily can be attributed to more frequent replenishment of nutrients in the digestive tract, which maintains a relatively continuous supply of energy and protein for somatic growth. Ndifor *et al.* (2022) observed this in *C. gariepinus* (African catfish) juveniles (initial mean weight  $17.6 \pm 3.7$  g). The 42-

day indoor trial used 80 L plastic tanks stocked at 15 fish per 50 L water. Fish received a commercial diet at 5% body weight, distributed three times daily (08:00, 13:00, and 18:00). Similar results were reported in previous studies where higher feeding frequencies improved growth rates in African catfish juveniles and fingerlings when total daily ration was adequately distributed into one time, two times, and three times (Abdel-Aziz *et al.*, 2021) or one time, two times, three times, and four times (Okomoda *et al.*, 2019). In contrast, once-daily feeding likely restricted the opportunity for continuous nutrient uptake, resulting in slower growth on African catfish when the total daily ration was 15% of body weight, despite the high survival recorded across all treatments (Okomoda *et al.*, 2019).

Feed utilization indices further supported the advantage of more frequent feeding. The lowest feed

FCR) and the highest FER and PER were obtained in T3. The exceptionally low FCR values across treatments suggest highly efficient conversion of feed into body mass under the experimental conditions. The progressive improvement in FCR, FER, and PER with increasing feeding frequency indicates better protein and energy utilization when meals are provided more often (Xu *et al.*, 2025). This pattern is consistent with the principle that frequent feeding can enhance digestive efficiency and reduce the metabolic cost associated with large single meals on red-tail catfish *Hemibagrus wyckioides* (Elesho *et al.*, 2021).

Survival rates remained high (95%–98%) and did not differ significantly among treatments. This suggests that the feeding regimes employed did not induce stress levels capable of compromising fish health or increasing mortality. The high survival further confirms that water quality parameters remained within tolerable limits for *C. gariepinus* throughout the trial (Essien *et al.*, 2026).

Water quality results showed that dissolved oxygen declined significantly as feeding frequency increased, with the lowest value recorded in the three times daily group. This reduction is most likely linked to higher metabolic activity, increased oxygen consumption by the fish, and greater organic loading from feed and fecal matter (Rosenfeld and Lee, 2022; Stavrakidis-Zachou *et al.*, 2025). Nevertheless, all dissolved oxygen values remained above the critical threshold for African catfish culture. Other parameters (pH, temperature, electrical conductivity, and total dissolved solids) showed no significant variation and stayed within recommended ranges (Akinwale *et al.*, 2016) indicating that the experimental system was adequately managed.

The present findings are consistent with earlier reports demonstrating enhanced growth and feed efficiency at elevated feeding frequencies. Kolawole *et al.* (2024), for instance, observed that African catfish fingerlings receiving three daily meals exhibited significantly greater weight gain and improved feed conversion ratios relative to those fed once or twice daily. Similarly, feeding two to three times daily, enhanced growth indices in *C. gariepinus* fingerlings (Aderolu *et al.*, 2017). In contrast, Oboh (2022) reported no significant growth differences among once-daily, intermittent, and twice-daily satiation regimes, attributing the outcome to compensatory hyperphagia, whereby fish on restricted schedules consumed larger quantities when feed was available.

Discrepancies between studies may arise from differences in ration allocation (fixed restricted rations versus satiation feeding), fish size (smaller fingerlings with higher metabolic demands versus larger juveniles), diet composition (rapidly digestible extruded feeds versus moist farm-made diets), or experimental duration. In the current investigation, the consistent performance ranking (T3 > T2 > T1) indicates that both total nutrient supply and its temporal distribution favored more frequent feeding, promoting steadier gut filling and nutrient absorption.

Although three times daily feeding yielded superior biological performance, practical considerations must be weighed. An additional daily feeding event on a medium-scale farm can increase labor by 1–2 hours, while more frequent feed introduction may slightly depress dissolved oxygen. Consequently, under commercial conditions where labor and aeration costs are substantial, twice-daily feeding often represents a pragmatic compromise between growth efficiency and operational feasibility.

## CONCLUSION

The study shows that feeding *Clarias gariepinus* juveniles three times daily optimizes growth and nutrient utilization without compromising survival, provided that water quality is carefully monitored. These findings contribute useful information for refining feeding strategies aimed at improving productivity in African catfish aquaculture.

The study was limited to six (6) weeks of feeding frequencies on African catfish, which do not fully capture long-term growth patterns or responses in fish performance and economic production. The experiment was conducted under controlled tank conditions; the result may not fully explain larger commercial pond and management practices. A detailed cost-benefit analysis (labor, feeds, and aeration cost versus biomass gain) was not quantified. The study also revealed that other water quality parameters, such as ammonia, microbial load, and nitrite that could affect the feeding frequency were not documented. Also, the study was tied to specific commercial diets and ration levels used in the trial.

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